



*exPEYES*

A portable  
Science Laboratory

<http://expeyes.in>

FOSS.IN 2012

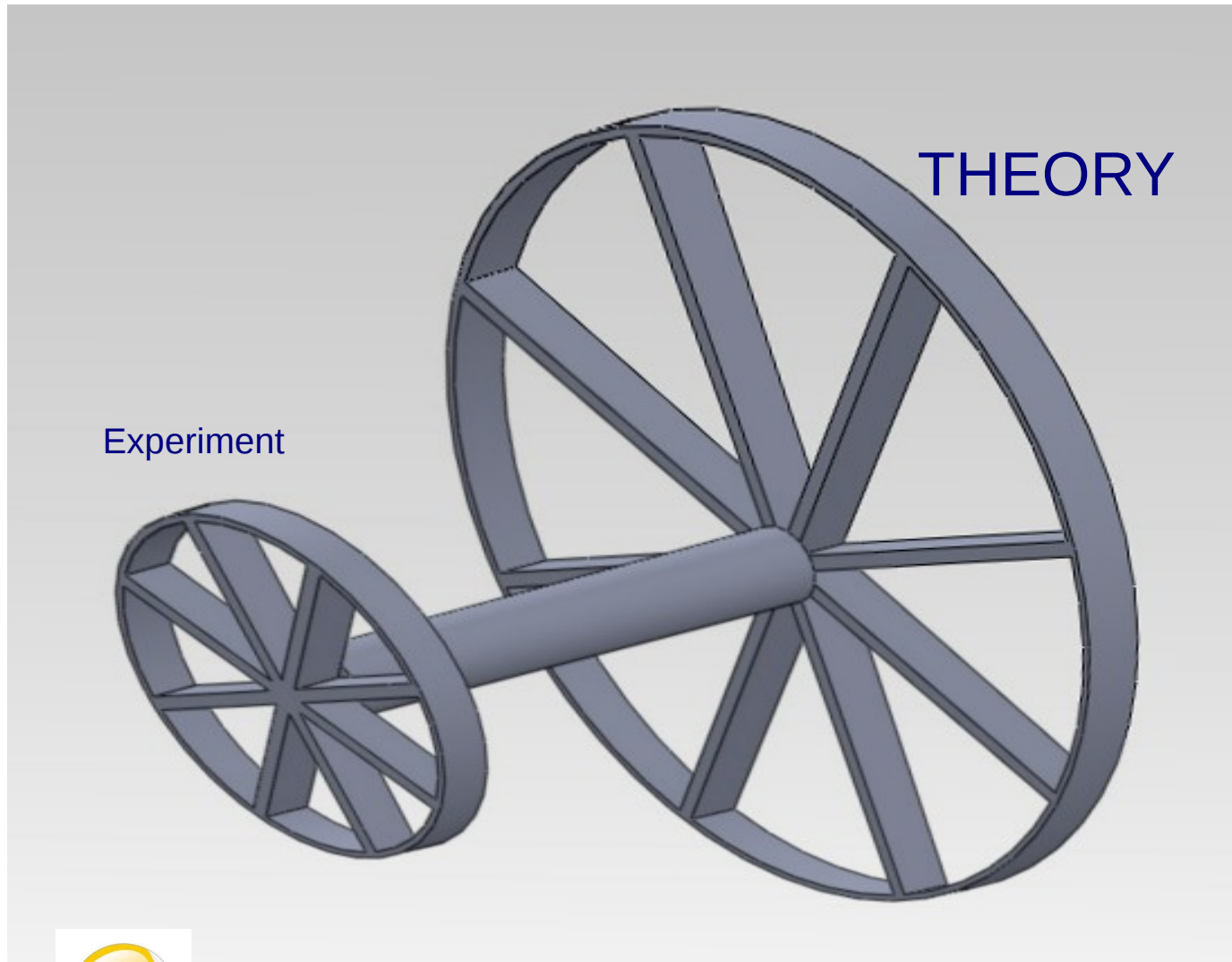
Ajith Kumar B.P.  
Inter-University Accelerator Centre  
New Delhi 110067

[ajith@iuac.res.in](mailto:ajith@iuac.res.in)    [www.iuac.res.in](http://www.iuac.res.in)

Result of a highly thought provoking and motivating lecture...



# Our Science/Engineering Education



.. and it goes in circles.

# Why Experiments are ignored in our Science Education ?

- Exam oriented evaluation system.
- Lack of interest.
- Lack of equipment.

The PHOENIX project, started by IUAC in 2005, tries to address the third issue, by designing cost-effective science/engineering experiments.

# What is expEYES ?

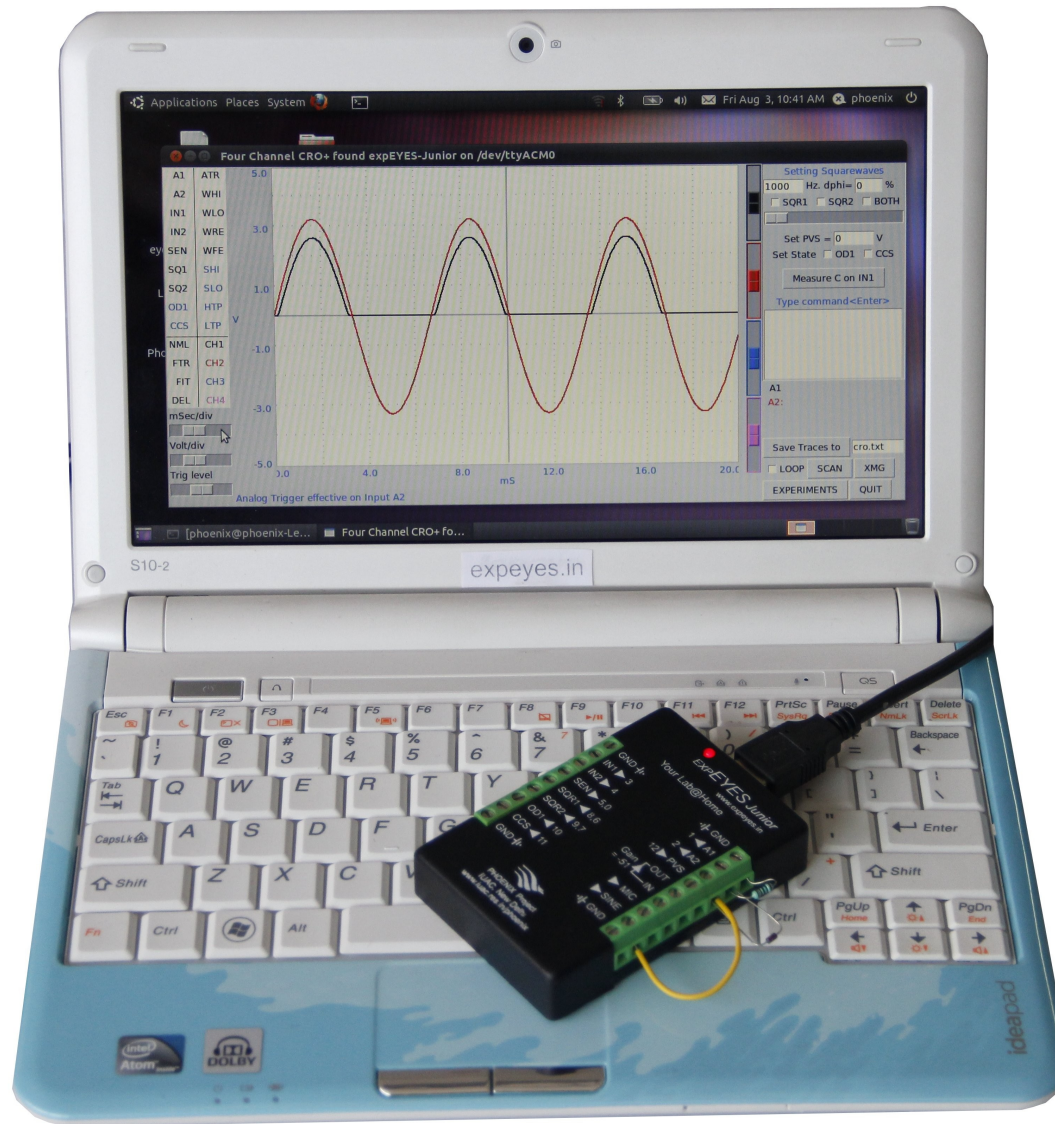
A low cost device that can generate/measure voltages as a function of time and generate graphs.

**A tool for learning by exploring.**

Supports Science & Engineering experiments from **High School to Post Graduate level.**

A test equipment for electronics hobbyists.

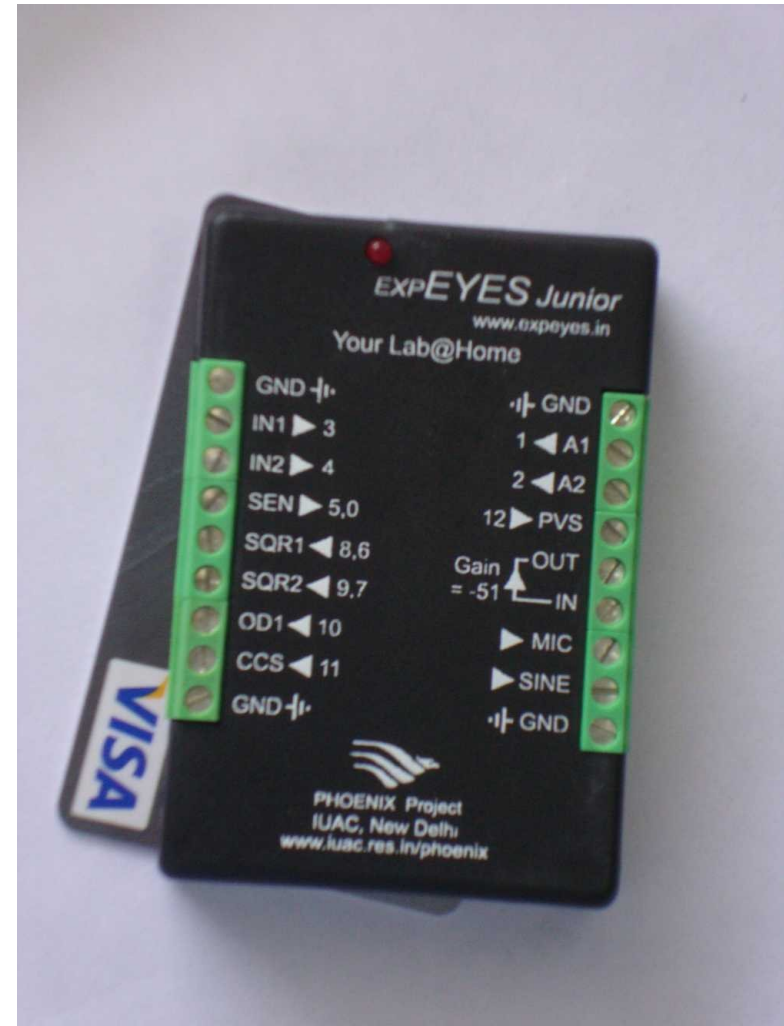
**All with Open Software & Hardware**



ExpEYES on a netbook, studying a PN junction Diode

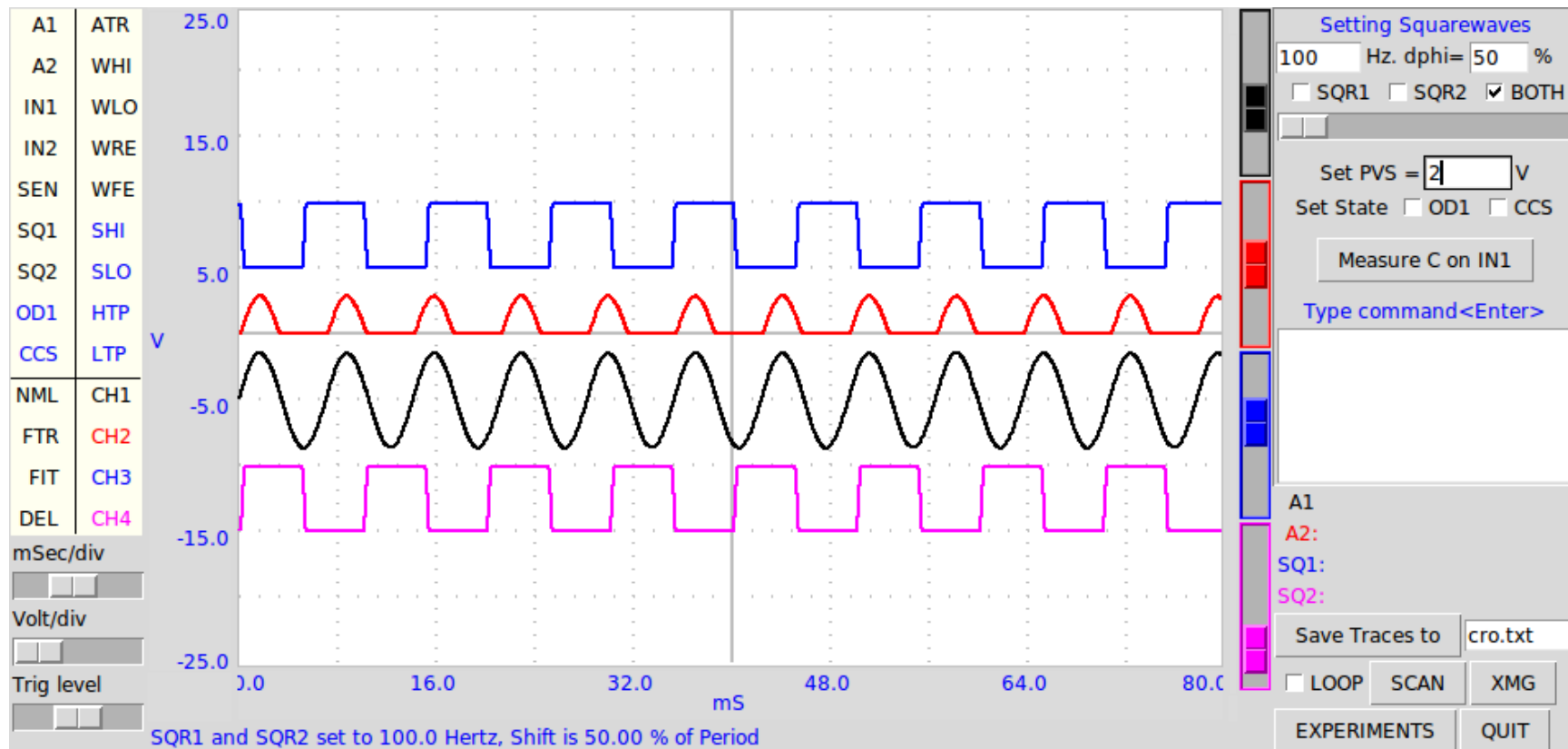
Features:

- 12 bit Analog Input/Output
- Digital I/O
- Time interval measurements
- Waveform Generation
- USB Powered
- GUI for 50 experiments
- Python Programmable
- Works as a Test Equipment
- $8.6 \times 5.8 \times 1.5 \text{ cm}^3$ , 60 gm.
- Open Hardware



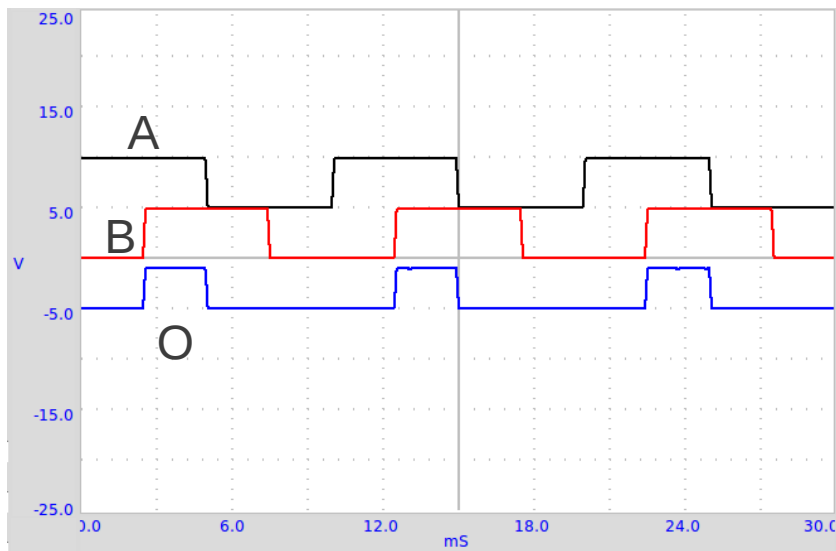
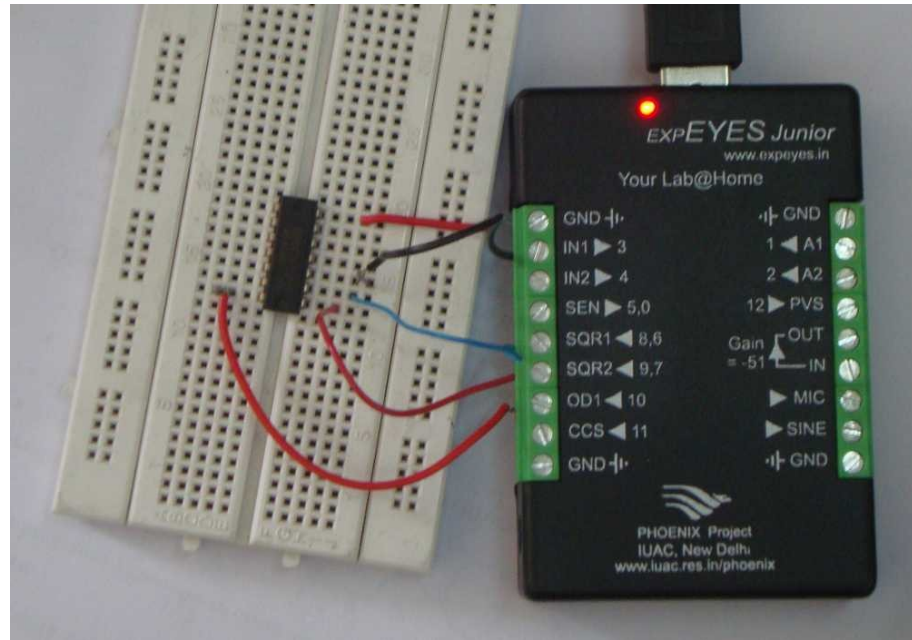
# GUI programs available for around 50 experiments

## Example 1: Four channel CRO (250 ksps)

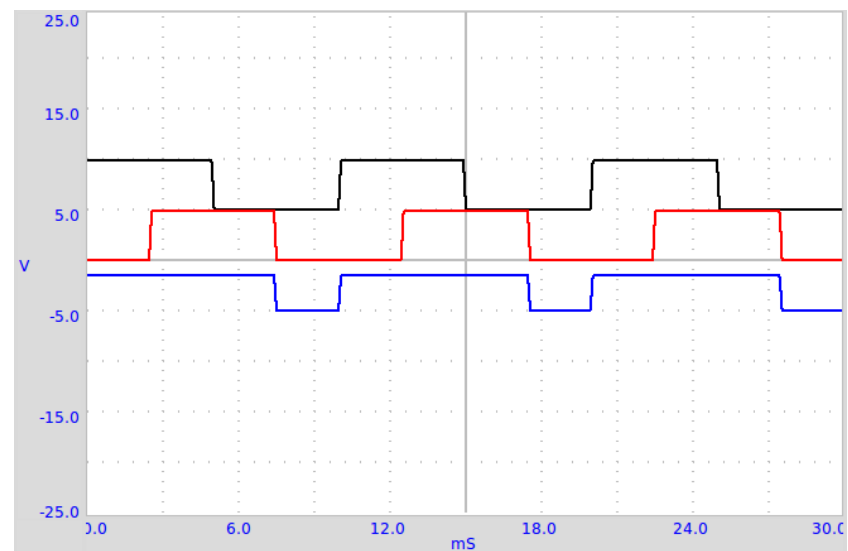




# Study of Logic Gates

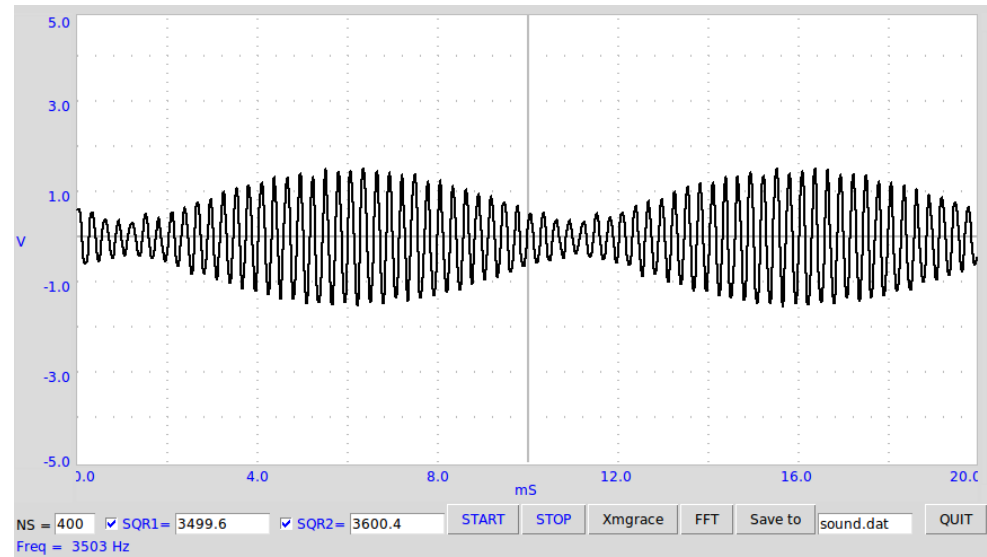
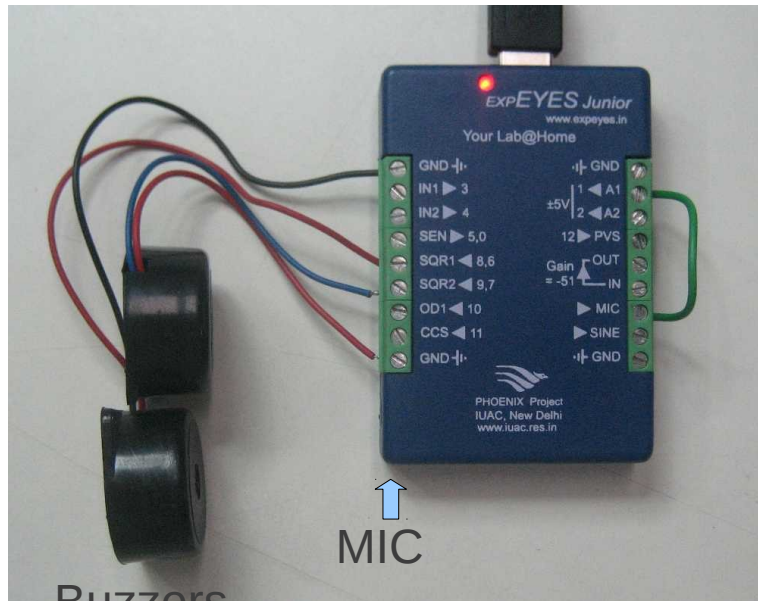


AND Gate

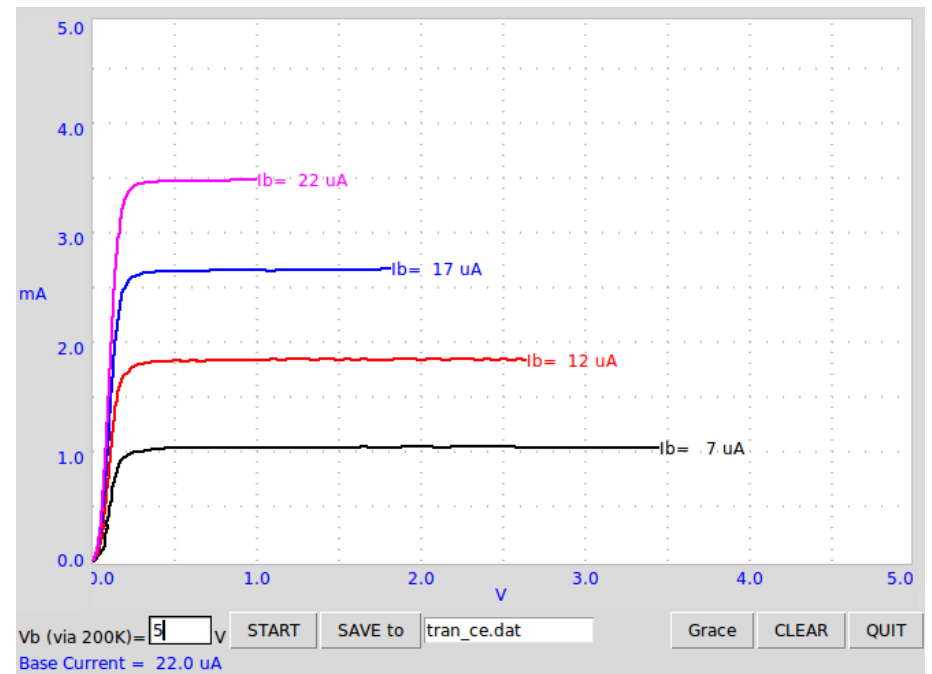
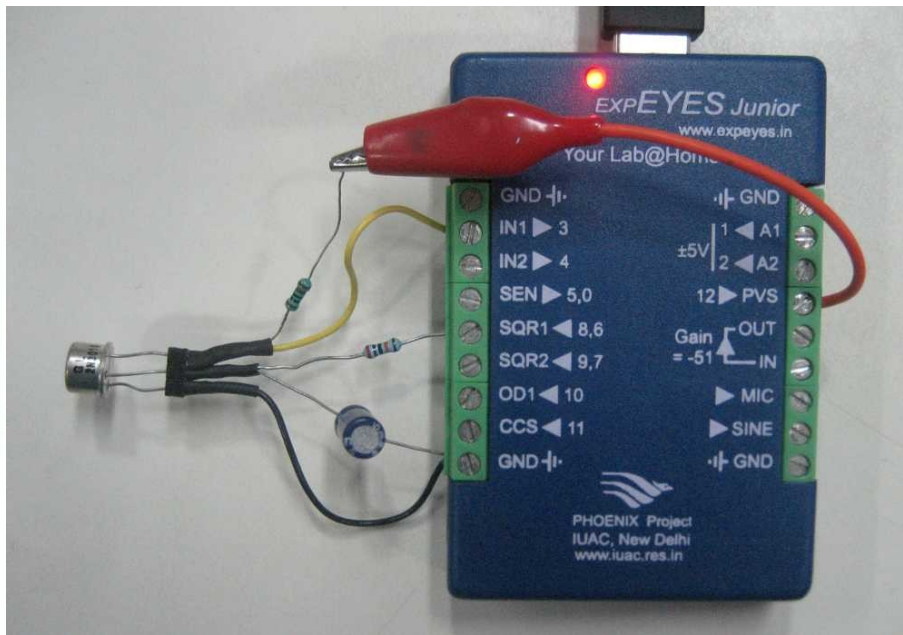


OR Gate

# Interference of Sound

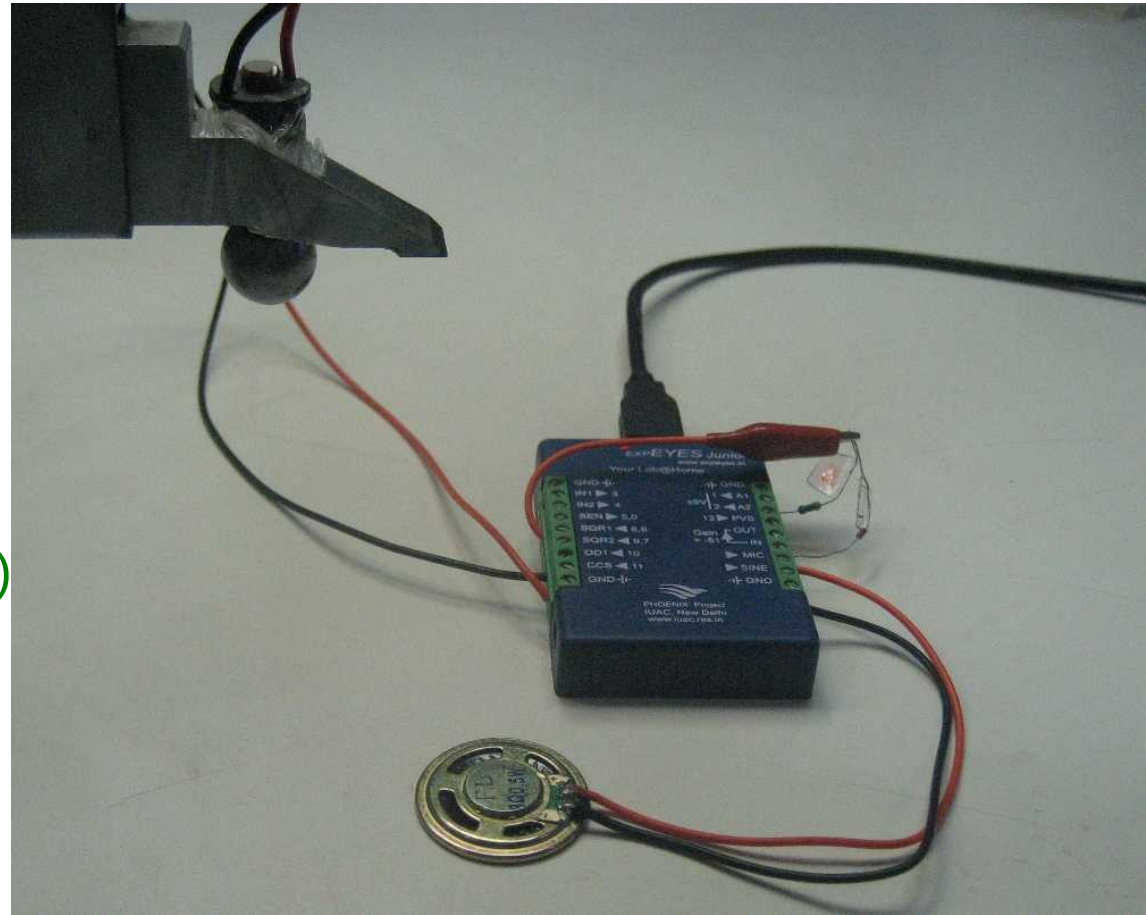


# Transistor Characteristics



# Acceleration due to Gravity, by Time of Flight

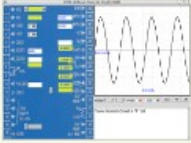
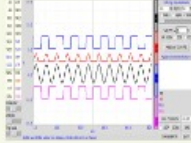

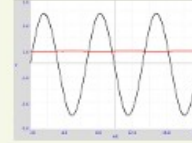



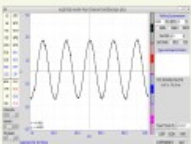


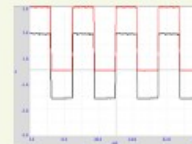
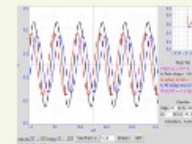
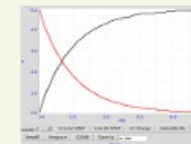
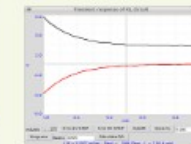
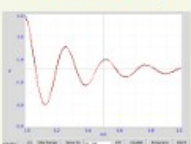
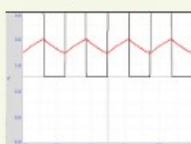
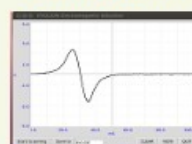

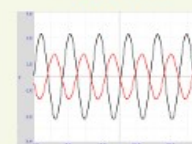





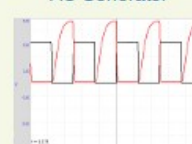

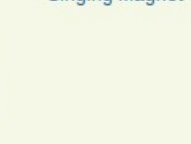




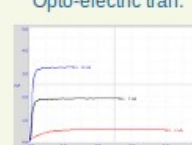

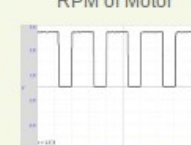

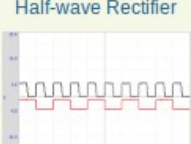

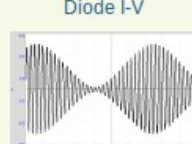



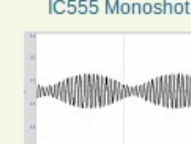
```
import expeyes.eyesj
p= expeyes.eyesj.open()
p.set_state(10,1)
raw_input('Ready')
print p.clr2rtime(10,0)
```



Electromagnet releases a metal ball and the loudspeaker generates a signal when it touches ground.

And many more ...

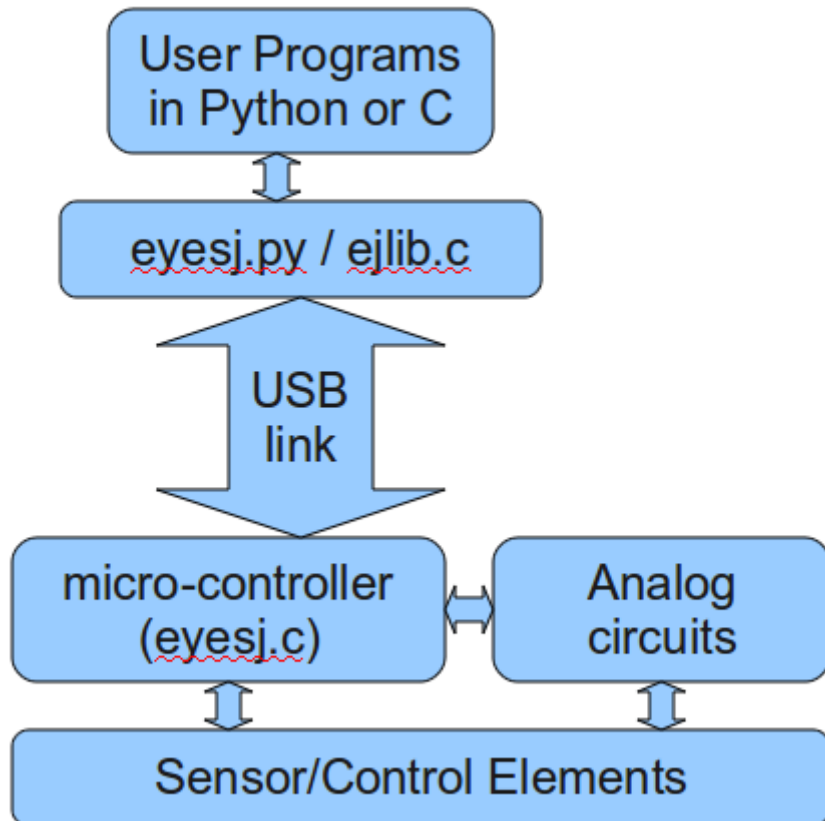
<http://expeyes.in>

 <p>expEYES GUI</p>	 <p>expEYES Junior GUI</p>	 <p>Measuring DC</p>	 <p>AC &amp; DC</p>	 <p>Resistance</p>	 <p>Resistance of water</p>	 <p>Infrared Comm.</p>
 <p>Powerline Pickup</p>	 <p>Capacitance</p>	 <p>Dielectric Constant</p>	 <p>AC &amp; DC Combined</p>	 <p>AC Circuits</p>	 <p>RC, Transient</p>	 <p>RL, Transient</p>
 <p>RLC, Transient</p>	 <p>RC Integration</p>	 <p>EM Induction</p>	 <p>AC Generator</p>	 <p>Transformer</p>	 <p>Singing Magnet</p>	 <p>Driven Pendulum</p>
 <p>Persistence of Vision</p>	 <p>Stroboscope</p>	 <p>Light Barrier</p>	 <p>Opto-electric tran.</p>	 <p>'g' using Pendulum</p>	 <p>RPM of Motor</p>	 <p>LDR</p>
 <p>Half-wave Rectifier</p>	 <p>Full-wave Rectifier</p>	 <p>Diode I-V</p>	 <p>Transistor CE</p>	 <p>Logic Gates</p>	 <p>IC555 Oscillator</p>	 <p>IC555 Monoshot</p>
 <p>Clock Divider</p>	 <p>Fourier Transform</p>	 <p>AM &amp; FM</p>	 <p>Filter Circuits</p>	 <p>Sound, Frequency</p>	 <p>Piezo Buzzer</p>	 <p>Sound Beats</p>

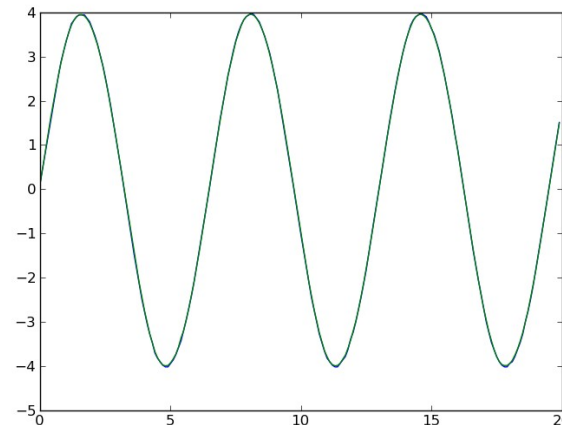
# Design of expEYES Junior

Real-time measurement features of Micro-controller  
+

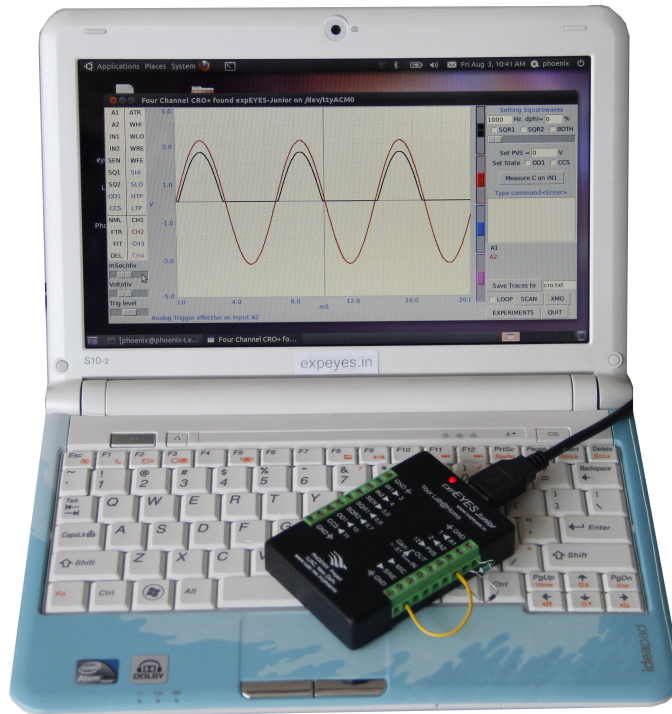
Computational and Graphics capability of Python.



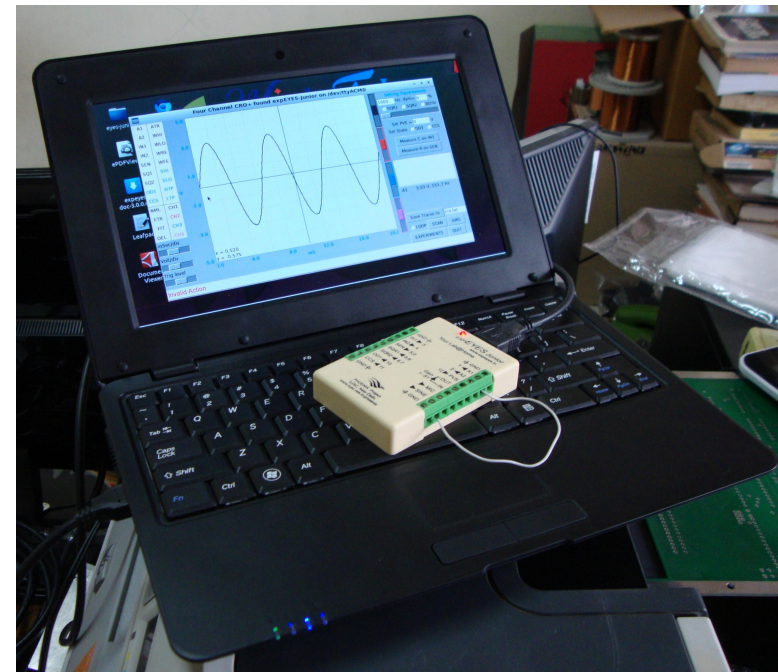
```
import expeyes.eyesj
p = expeyes.eyesj.open()
from pylab import *
t,v = p.capture(1, 200, 100)
plot(t,v)
show()
```



# Reducing total cost: cheaper computers.

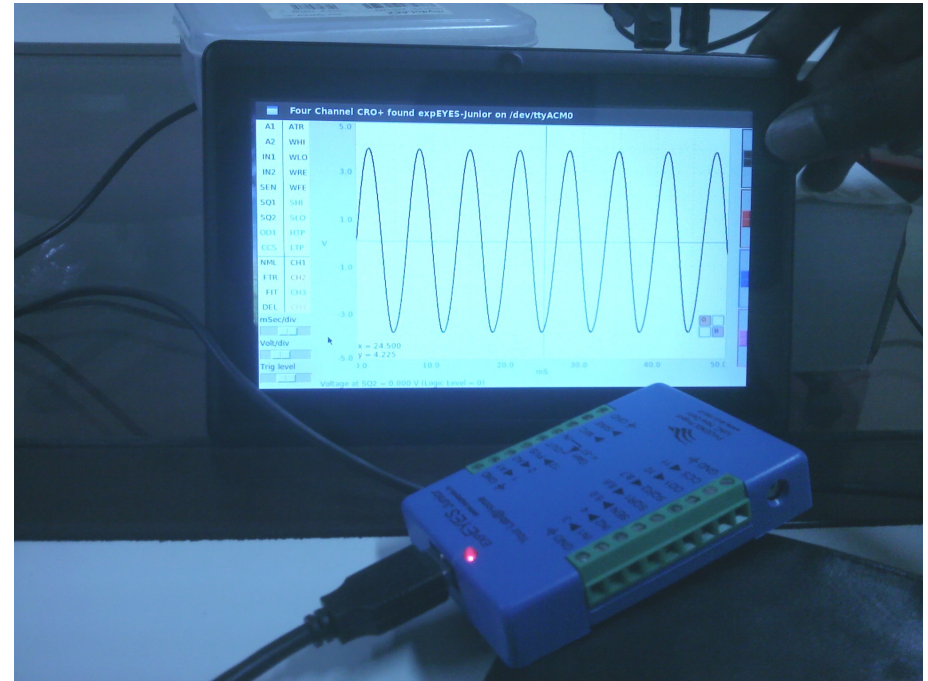
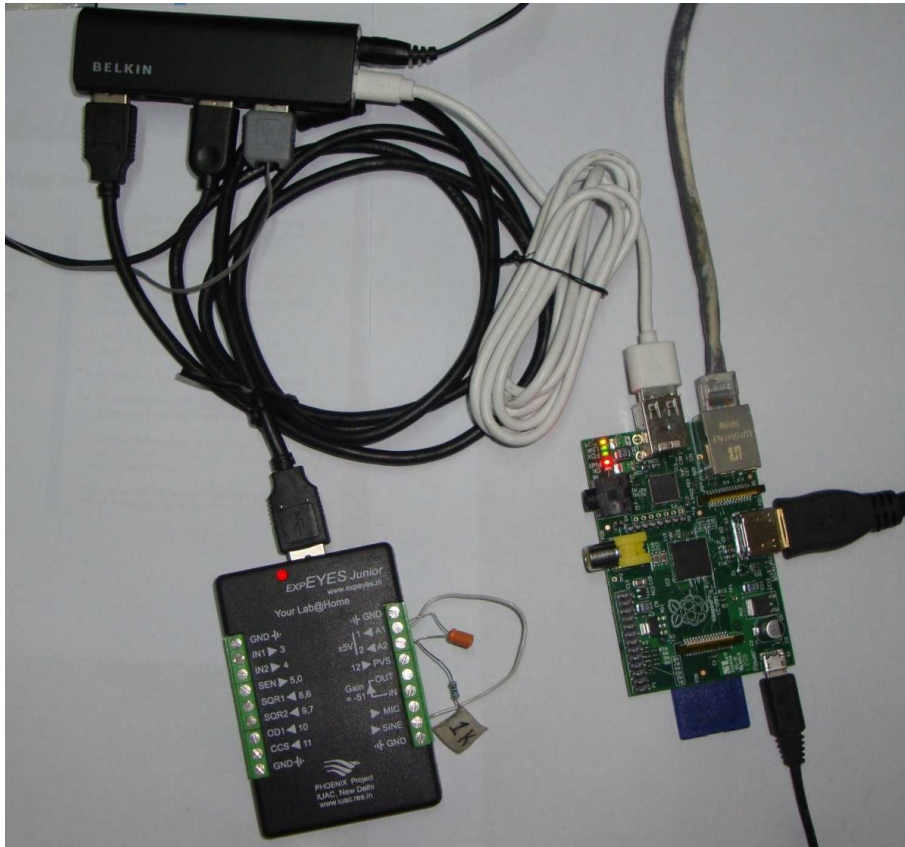


Netbooks with Atom processor.  
Costs around 13000/-



ARM processor based Netbook  
around 7000/- from Wishtel

# Tested on Raspberry Pi and Aakash2



By Aakash2 team, IIT, Bombay

Combined with Aakash2, total cost of setting up a lab is around Rs. 3000/-



## What is expEYES for

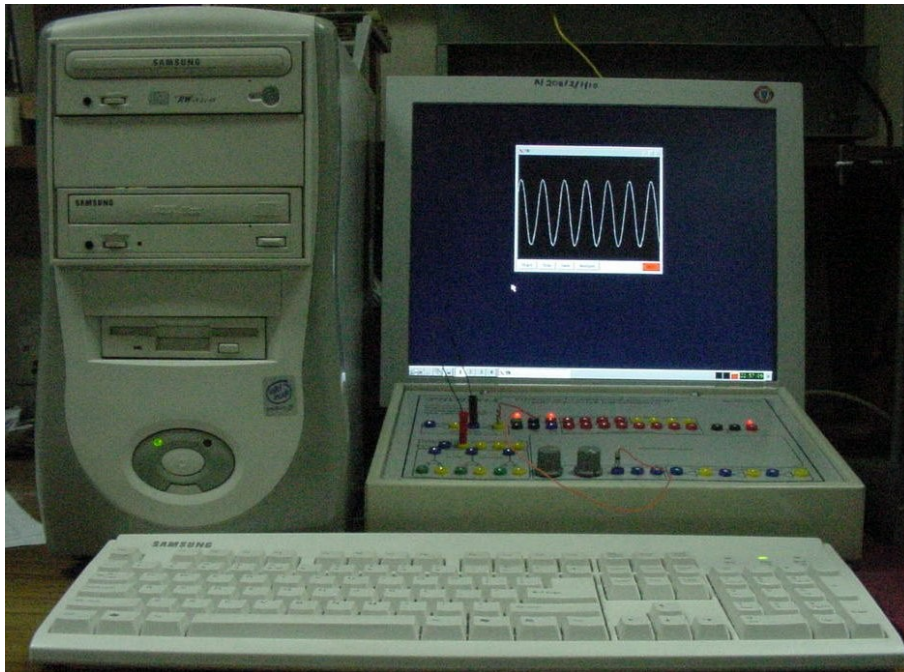
**Students** : An affordable tool for doing experiments, anytime anywhere. Freedom from the lab timings.

**Teachers** : A tool for doing demos, experiments and to develop new experiments.

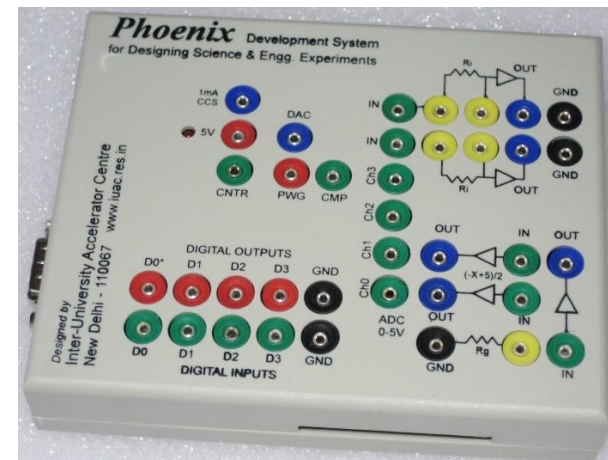
**Engineers** : An open system that combines basic physics, electronics, micro-controller programming, computer interfacing, GUI programming and scientific computation.

**Hobbyist** : A nice tool to kill more time with less money.

The PHOENIX project was started in 2005, with the objective of developing cost effective experiments for teaching science.



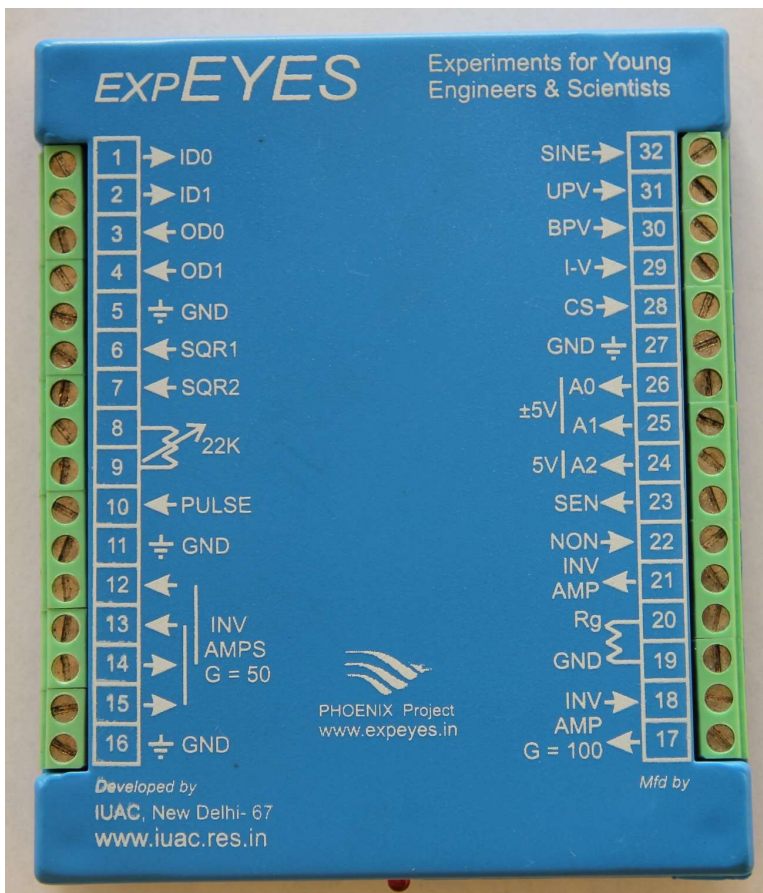
2005 : Parallel port device,  
Linux / DOS  
C code



2006: micro-controller version  
RS232 / USB options.  
Python code

## 2011: expEYES

- USB Powered
- 12 bit ADC/DAC
- 11x9x1.5 cm, 150 gm
- Rs. 3000/-

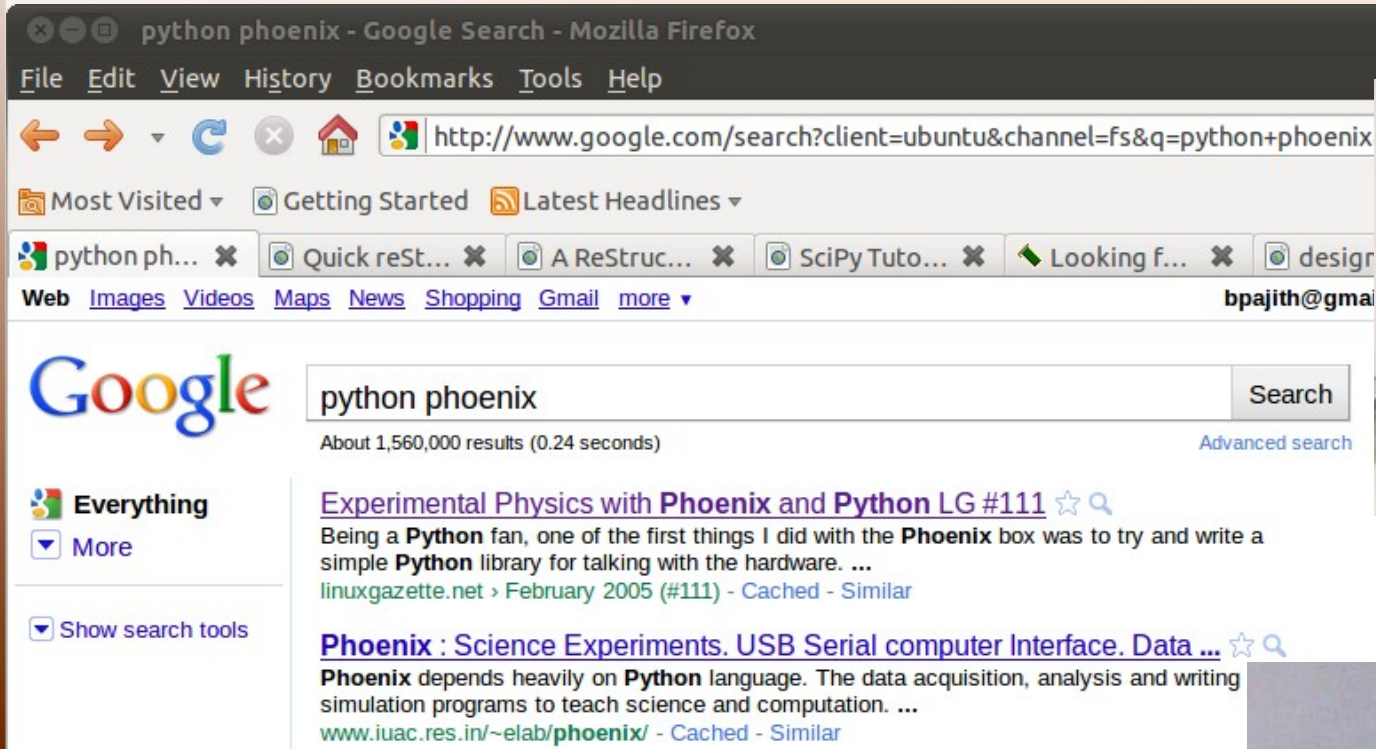


## 2012: expEYES Junior

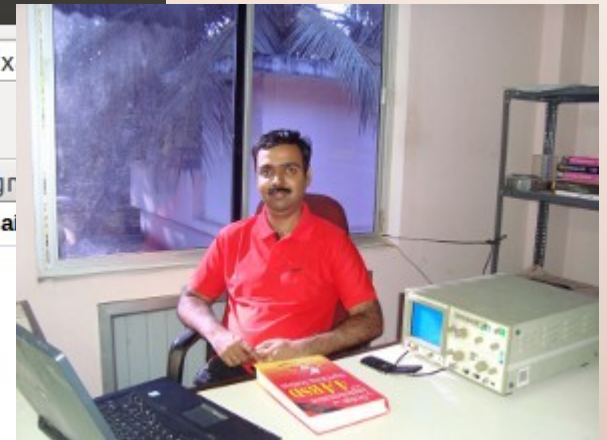
- USB Powered (70 mA@5V)
- 12 bit ADC/DAC
- 8.6x5.8x1.6 cm, 60 gm.
- Rs. 1600/-



# The reptile creeps in.. (from C to Python)



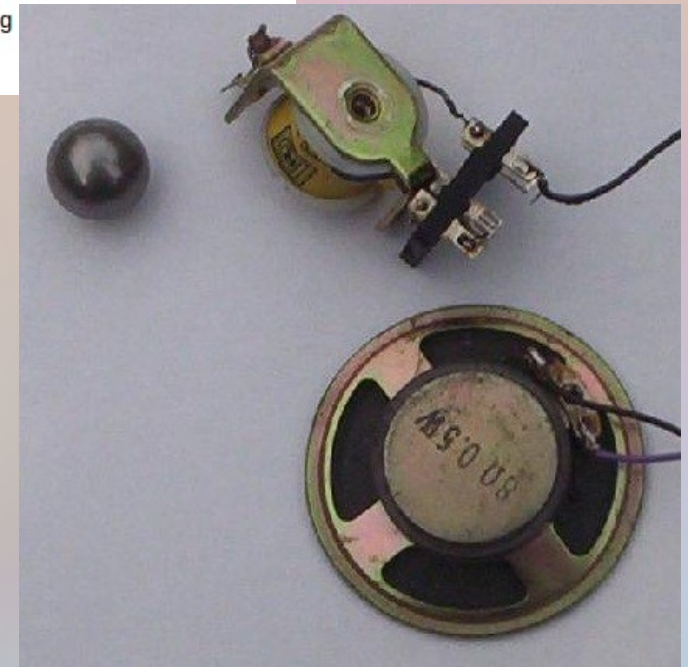
The screenshot shows a Mozilla Firefox browser window with the address bar containing the URL `http://www.google.com/search?client=ubuntu&channel=fs&q=python+phoenix`. The search results for 'python phoenix' are displayed, showing approximately 1,560,000 results. The top result is 'Experimental Physics with Phoenix and Python LG #111' from linuxgazette.net, dated February 2005. The second result is 'Phoenix : Science Experiments. USB Serial computer Interface. Data ...' from www.iuac.res.in/~elab/phoenix/.



<http://pramode.net>

## Value of 'g' from Time of Flight, (using electromagnet, ball & speaker)

```
from phoenix import *  
p = Phoenix()  
p.write_motors(0xf) # Energize the coil  
t = p.get_drop_time() # Drop the ball and time it!  
print t
```



## Status of PHOENIX Project

- More than 1000 units are in circulation.
- Included in the syllabus in some Universities.
- Trained around 300 physics teachers.
- Conducted around 35 awareness programs at different places.

Every year IUAC conducts two  
“Six days training programs on PHOENIX”

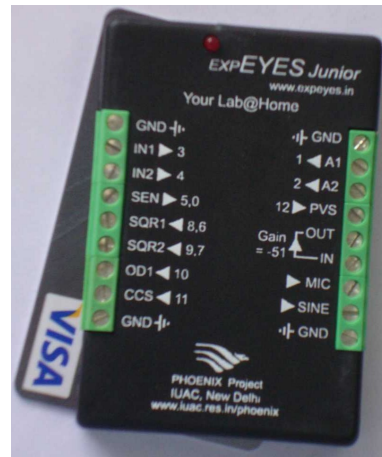
# Phoenix at Lycée Jean Bart, France



Georges Khaznadar, Science teacher & Debian developer.  
Volunteers for PHOENIX Project

# Project Objective

Make high quality laboratory equipment available to every science student, by making it affordable.



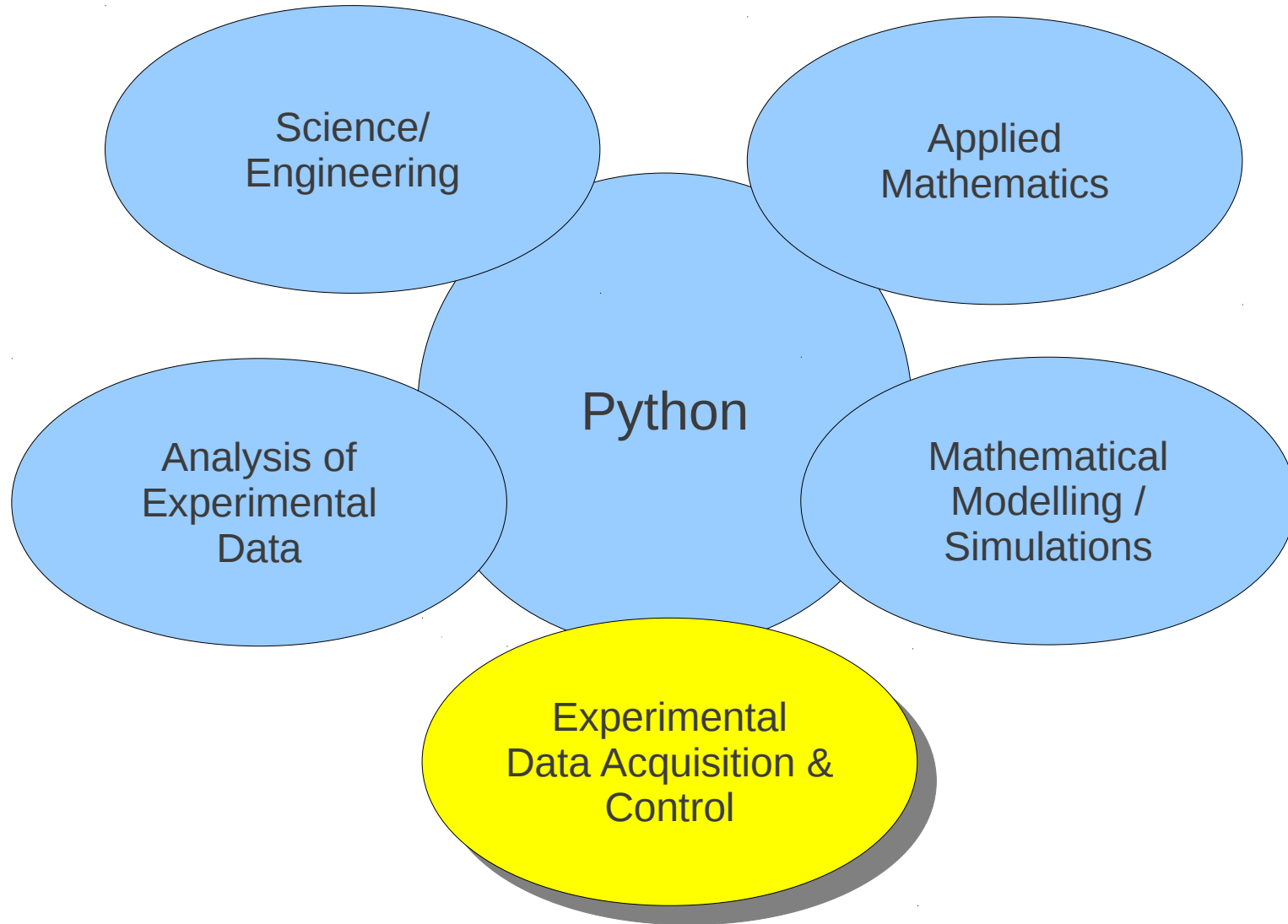
US\$ 30



US\$ 2.0

Both contains almost same amount of hardware.  
Mass production makes the cost difference.

# Role of Python in Science & Engineering Education





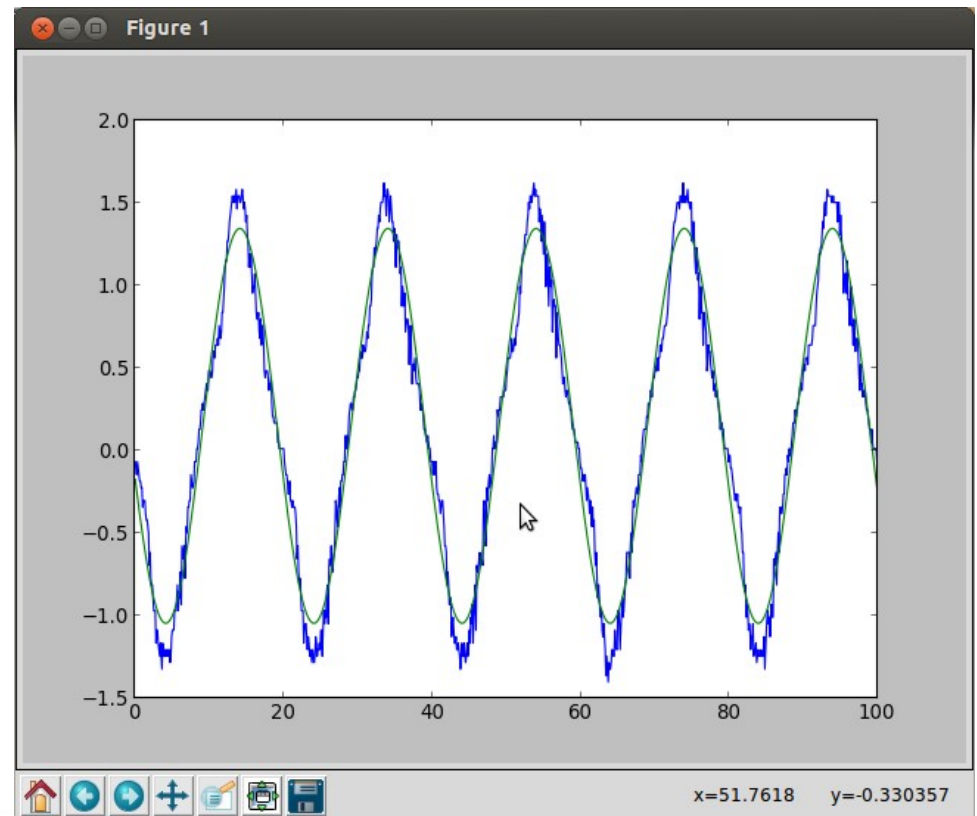
# Data Analysis & Visualisation (AC mains pickup signal)

```
from pylab import *  
import expeyes.eyesj, expeyes.eyemath as em  
p=expeyes.eyesj.open()
```

```
t,v = p.capture(1,1000, 100)  
vf, par = em.fit_sine(t,v)
```

```
plot(t,v)  
plot(t,vf)  
print par[1]*1000  
show()
```

50.1209437171

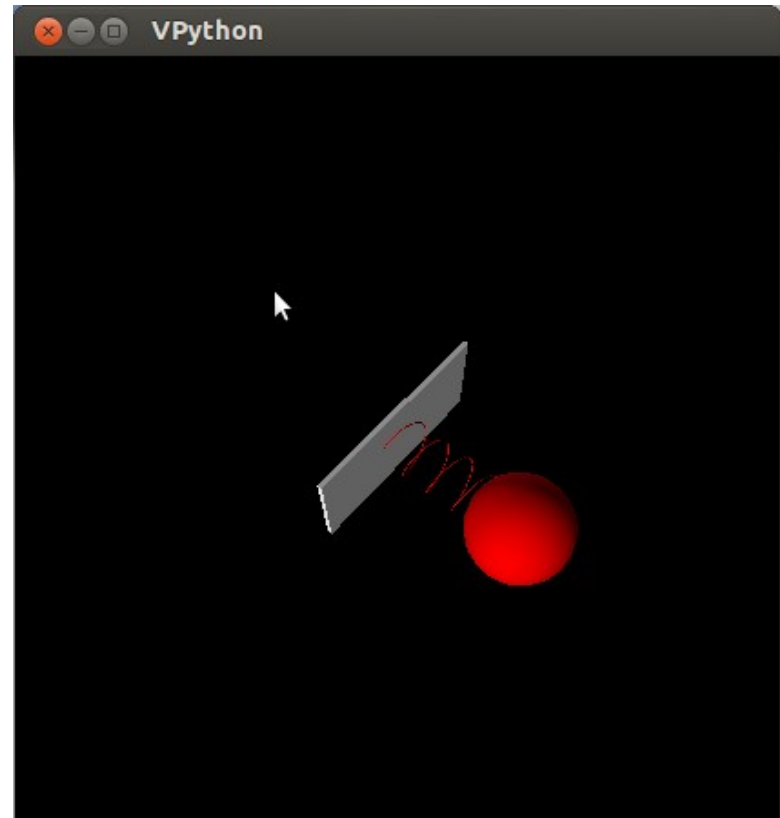


# Simulations: The mass & spring problem

```
from visual import *  
wall = box (pos=(0,0,0), length=0.1, height=2, width=4, color=color.white)  
ball = sphere (pos=(4,0,0), radius=1, color=color.red)  
spring = helix(pos=(0,0,0), axis=(4,0,0), radius=0.5, color=color.red)
```

```
t = 0.0  
dt = 0.01  
x = 2.0  
v = 0.0  
K = 100.0    # Spring constant  
M = 1.0      # Mass attached
```

```
while 1:  
    rate(20)  
     $f = -k * x$       # Equation to solve  
     $v += (f/m) * dt$   
     $x = x + v * dt$   
    t = t + dt  
    spring.length = 4 + x  
    ball.x = x + 4
```



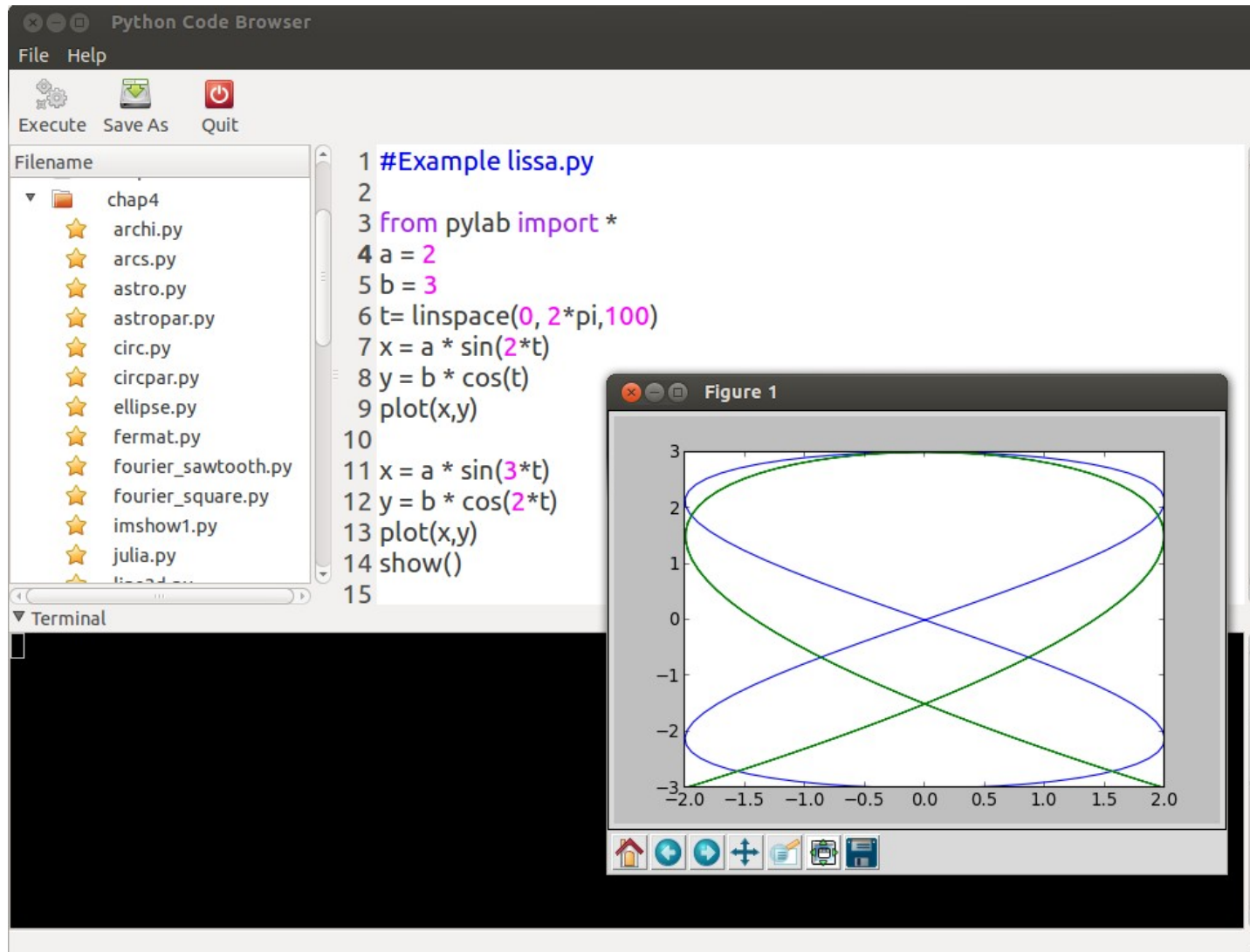
## Attempts to include Python in the Syllabus

- West Bengal State University
  - MSc Physics
- IISER, Kolkata
  - MS courses
- University of Calicut, Kerala
  - BSc Mathematics
  - BSc & MSc Physics

(there may be more)

It would help if more institutions do it.

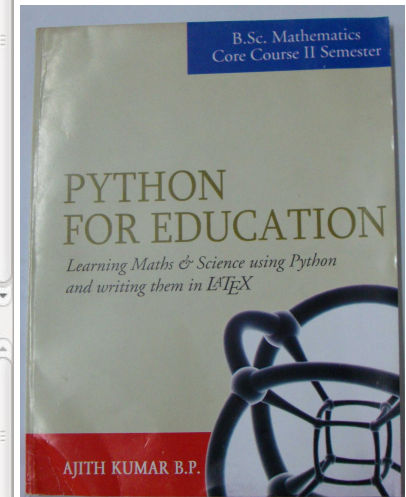
# Python book and Code Browser



The screenshot displays the Python Code Browser interface. On the left, a file explorer shows a directory named 'chap4' containing various Python files. The main editor area shows the following code:

```
1 #Example lissa.py
2
3 from pylab import *
4 a = 2
5 b = 3
6 t= linspace(0, 2*pi,100)
7 x = a * sin(2*t)
8 y = b * cos(t)
9 plot(x,y)
10
11 x = a * sin(3*t)
12 y = b * cos(2*t)
13 plot(x,y)
14 show()
15
```

Below the code is a terminal window. To the right, a window titled 'Figure 1' displays a plot of two Lissajous curves. The x-axis ranges from -2.0 to 2.0, and the y-axis ranges from -3 to 3. The plot shows two intersecting closed curves, one blue and one green, forming a complex, symmetric shape.



Python book  
under GNU FDL

Download from <http://expeyes.in/python-programming>

For details visit <http://expeyes.in>



The screenshot shows a web browser window with the URL [expeyes.in](http://expeyes.in). The website header features the ExpEYES logo, which consists of a stylized eye shape with colorful waves. Below the logo is the text "ExpEYES ... Your Lab@Home" and "Low Cost Science Experiments using Computers". A navigation menu includes links for HOME, HOW TO BUY, MICROHOPE, SOFTWARE, PYTHON, and PEOPLE. A blue banner below the menu reads "Experiments for Young Engineers and Scientists".

The main content area is titled "expEYES" and features two product images. The left image shows a laptop with a blue circuit board connected to its keyboard. The right image shows a similar setup with a black circuit board. Text between the images lists product features and specifications. At the bottom of the page, a paragraph describes the project's origin and goals.

**expEYES**

A tool for learning science by exploration and experimenting.  
50 documented experiments and easy to add more.  
Wide range, High school to PG level.  
Built-in Signal Generator and CRO.  
USB Powered.  
12bit analog resolution.  
Microsecond timing resolution.  
Open Hardware & Free Software.  
Software in Python language.  
Compact, 8.6x5.8x1.6 cm, 60 gm  
Low Cost, 2 models available.

<-- expEYES | | expEYES Junior-->

ExpEYES is from the PHOENIX project of Inter-University Accelerator Centre, New Delhi. It is a hardware & software framework for developing science experiments, demonstrations and projects without getting in to the details of electronics or computer programming. PHOENIX (Physics with Home-made Equipment and Innovative Experiments) project was started, in 2005 as a part of IUAC's outreach program, with the objectives of developing affordable laboratory equipment and training teachers. Design of ExpEYES combines the real-time measurement capability of micro-controllers with the ease and flexibility of Python programming language for data analysis and visualisation. Software for all products from PHOENIX are distributed under GNU

## Hardware Availability

8 + 1 sources, More are welcome

ExpEYES is currently available from the following firms:

### **Shankar Systems**

Plot 21, Gali 6/2, Block C,  
Dechave Enclave,  
Najafgarh, NEW DELHI-110043.  
Ph: 9810841403

*email : [sankar\\_systems at sify.com](mailto:sankar_systems@sify.com)*

### **Zyxware Technologies Pvt. Ltd.**

3/2457(6), TDK Road, Marappalam  
Pattom P.O.  
Thiruvananthapuram  
Kerala 695004

*email : [info at zyxware.com](mailto:info@zyxware.com)*

### **Mumbai**

Amit Dhakulkar  
Ph : 9819350953

*email : [damitr at gmail.com](mailto:damitr@gmail.com)*

### **S2S2 Services**

TV 33/268, Third Floor Elite Complex  
Netaji Road, Kannur 670 001  
Kerala  
Ph: 9447449107

*email : [s2s2service at gmail.com](mailto:s2s2service@gmail.com)*

### **Vibrant Systems and Softwares**

1/4869H, 1st Floor Koyisco Building,  
Wyanad Road, East Nadakkavu,  
Calicut-673011.  
Ph: 9847193371.

*email: [vibsys\\_n\\_soft at yahoo.com](mailto:vibsys_n_soft@yahoo.com)*

### **Sys-Con Engineering**

53B Mirza Galib Street  
Kolkata 700 016  
Ph: 9830417377 , 033 40014680

*email : [sceskms at yahoo.com](mailto:sceskms@yahoo.com)*

### **Hackable Devices**

40 passage des panoramas  
75002 Paris  
France  
(online store)

### **S V Techno Crafts**

86, J.D.Nagar, Patamata  
Vijayawada - 520010  
Ph: +91 866 2553364  
*email : [info at svtechnocrafts.in](mailto:info@svtechnocrafts.in)*

### **Fab to Lab (Order Online)**

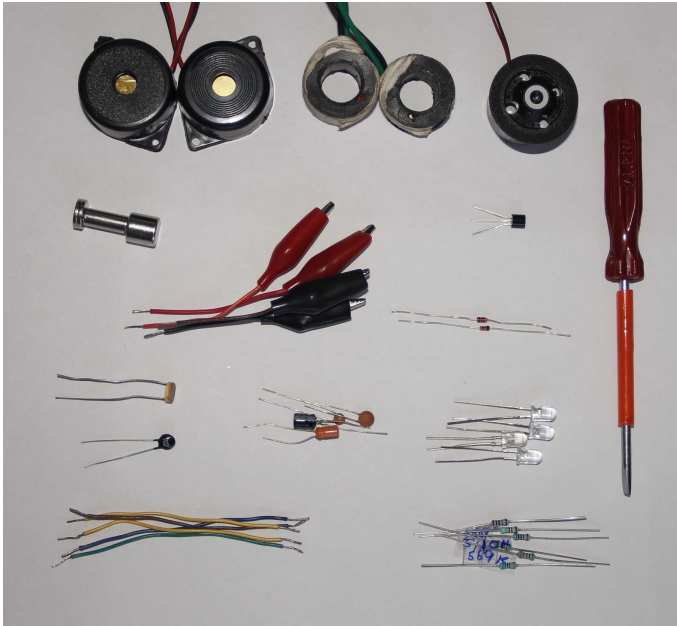
#41, Pentagon Passiflora  
Sarjapur, Bangalore - 562125  
Ph: +91 80 95782777  
*email: [sales at fabtolab.com](mailto:sales@fabtolab.com)*

Open Hardware: Schematics & PCB files are on the website

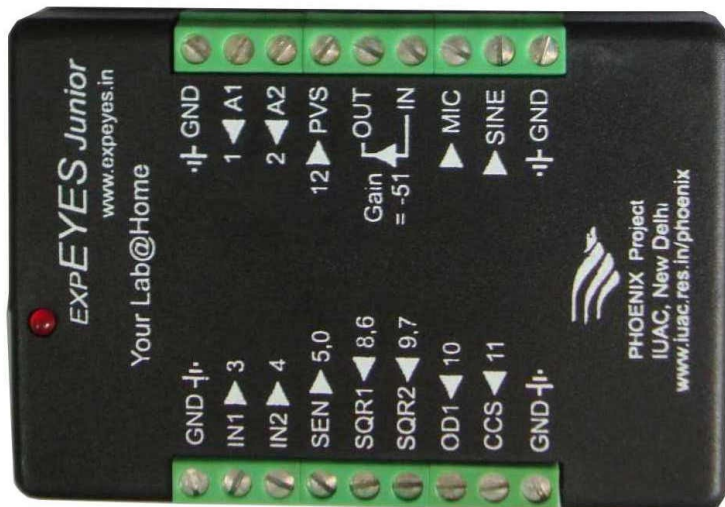
Software Distribution:

- LiveCD
- Debian Packages (part of Debian & Ubuntu repositories)
- Python Source files (for Windows etc.)

Many of the Control/Sensor elements are made from components used in consumer electronics.



Rs. 1600/-



Interface + Standard Accessory Set + LiveCD

Other commercially available equipment providing similar facilities.



Pasco



Vernier

Proprietary products (closed source), not affordable to developing countries.





Thank You